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FINAL REPORT ON

"RADAR BACKSCATTER FROM THE SEA  
CONTROLLED EXPERIMENTS"

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FINAL REPORT ON  
"RADAR BACKSCATTER FROM THE SEA:  
CONTROLLED EXPERIMENTS"

Richard K. Moore, Principal Investigator

This is the final report on ONR Grant N00014-89-J-3022. Since most of the work was in journal articles, conference proceedings, and reports, this report is brief.

Work continued, and was largely concluded, on analysis of the TOWARD, SAXON-CLT, and NILDEX data sets. Comparison between optical and radio measurements of ripple spectra at TOWARD showed favorable results. Although the wind direction was usually unfavorable for SAXON-CLT, we obtained useful data on modulation in the crosswind direction. We also demonstrated that a vector slope gauge can work, but for logistic reasons its deployment made its footprint close to the tower. Hence, the data are useful only for proof of concept, not for oceanographic application.

A new theory of SAR imaging of the ocean was developed. It incorporates elements of previous theories, but shows an improved way to find out the effects of signal modulations on the observed spectra. It confirms, by a different method, the results from several other theoretical and experimental studies on processor focus adjustment. These show optimum image contrast occurs for along-track wave motion when the processor is set to  $(\text{phase velocity})/2$ . The method of analysis used allowed closer examination of the basis for the two-scale (Bragg resonance with slope modulation) model for ocean backscatter. The results cast some doubt on the validity of the Bragg-scatter model for explaining many observed phenomena.

We built a 35-GHz radar to measure backscatter from the sea at mm wavelengths. It was successfully tested on a local lake and Lake Washington. This radar, with the addition (under grant N00014-89-J-3221) of a power amplifier, a 3-beam antenna, and a new control system, forms the basis for the high-performance vector slope gauge now in use at SAXON-FPN.

A list of publications and presentations resulting from this grant follows.

Statement "A" per telecon Dr. Frank Herr. Office of Naval Research/code 1121RS.

VHG

12/05/90



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**PUBLICATIONS FROM ONR-SPONSORED WORK**

**GRANT N00014-89-J-3022**

**RICHARD K. MOORE, PRINCIPAL INVESTIGATOR**

**"RADAR BACKSCATTER FROM THE SEA--CONTROLLED EXPERIMENTS"**

**Journal Publications**

West, J. C., R. K. Moore, J. Holtzman & S. Gogineni, "The modulation of the radar cross section of the ocean surface by an azimuthally traveling long gravity wave," *J. Geophys. Res.*, **94**, C11, 16,177-16,187, 1989.

Hesany, V., R. K. Moore, S. Gogineni & J. Holtzman, "Slope-induced non-linearities on SAR imaging of ocean waves," accepted January 1990 for publication in *IEEE J. Oceanic Engn.*

Lawner, R. T., P. F. Blanchard & S. Gogineni, "Coherent FM-CW millimeter-wave radar systems for radar cross-section measurements," *IEEE Trans. on Instrument. & Msmt.*, **39**, 1, 208-211, 1990.

West, J. C., R. K. Moore & J. C. Holtzman, "The slightly rough model in radar imaging of the ocean surface, *Int. J. of Rem. Sens.*, **11**, 617-638, 1990.

West, J. C., P. A. Hwang, R. K. Moore, J. C. Holtzman & O. H. Shemdin, "The modulation of a radar signal from the ocean surface due to slope and hydrodynamic effects, *J. Geophys. Res.* 2nd TOWARD issue, in press, 1990.

**Conference Presentations**

Hesany, V., R. K. Moore, J. C. West, J. C. Holtzman & D. I. Rummer, "Measuring local slopes of the sea: a radar vector slope gauge," *Digest IGARSS'89*, IEEE 990CH2768-0, Vancouver, BC, 10-14 July 1989, 1926-1928.

West, J. C., R. K. Moore & J. C. Holtzman, "The slightly rough-facet model in radar imaging of the ocean surface," *Digest IGARSS'89*, IEEE 990CH2768-0, Vancouver, BC, 10-14 July 1989, 1929-1932.

**RSL Technical Reports**

West, J. C., "Image: a computer program to simulate synthetic-aperture-radar imaging of ocean waves," RSL Technical Report 4191-9, June 1989.

West, J. C., "Synthetic-aperture-radar imaging of azimuthally propagating ocean waves," RSL Technical Report 4191-10, June 1989.

West, J. C., "The slightly-rough facet model in radar imaging of the ocean surface," RSL Technical Report 4191-11, June 1989.

West, J. C., "Synthetic-aperture-radar imaging of the ocean surface using the slightly-rough facet model and a full surface-wave spectrum," RSL Technical Report 4191-12, July 1989.

Moore, R. K., "Final Report on 'Radar Backscatter from the Sea: Controlled Experiments,'" RSL Technical Report 4191-13, November 1990.

RSL Technical Memoranda

West, J. C., "Removal of EMI noise from SAXON-CLT data," RSL Technical Memorandum 4191-12, June 1989.

West, J. C., "The measured Doppler frequency for multiple ocean waves from a tower-based radar," RSL Technical Memorandum 4191-13, June 1989.

West, J. C., "Curvature: a program to calculate the radius of curvature of the ocean surface," RSL Technical Memorandum 4191-14, June 1989.